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After the fire: assessing the microhabitat of *Capensibufo rosei* (Hewitt, 1926)

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Abstract. Rose's dwarf mountain toadlet, *Capensibufo rosei* (Hewitt, 1926), is endemic to fire-dependent, montane fynbos vegetation on South Africa's Cape Peninsula. The area undergoes natural fire cycles that are disrupted due to increasing urban pressure from the City of Cape Town. In this natural history observation, we report on *C. rosei* microhabitats used and their distribution immediately after a wildfire that swept through the area in March 2015. We found that a substantial number of adult toadlets had survived the fire, and that they were located within 160 m of a known breeding site. Animals were consistently found inside burrows, presumed to have been excavated by small rodents. Our observations have important consequences on the conservation of this IUCN Critically Endangered species, especially with relation to compaction of areas in the immediate vicinity of breeding sites. We emphasise the importance of making natural history observations following extreme events, such as fire, to provide important insights into conservation of cryptic threatened species.

Keywords. Bufonidae, burrows, compaction, fire, fynbos

Introduction

Located at the southwestern extreme of the African continent is the Cape Floristic Region, the smallest of six global floral kingdoms but with exceptionally high floral species richness and endemicity (Allsop et al., 2014). The shrub-like 'fynbos' vegetation is maintained through fire cycles of between 5–20 years, and this has played a key role in genesis of the floristic biodiversity since the fire regime began in the mid-Miocene (around 15 Mya; Cowling, 1987; Bytebier et al., 2011). Although fires are part of a natural cycle, areas in close proximity to dense human habitation have seen increases in the frequency of fires and subsequent suppression, leading to concerns about the change in fire regime on fynbos conservation (e.g., Kraaij and van Wilgen, 2014; Slingsby et al., 2020). In addition to the exceptional floral diversity, fynbos has a distinct anuran amphibian fauna, with many lineages exhibiting high endemism in both high- and lowland areas (e.g., Poynton, 1964; Schreiner et al., 2013; Colville et al., 2014). Transformation of the lowlands has resulted in many amphibians receiving a threatened status, while upland species are primarily threatened by invasive plants and the increase of fire frequency associated with human habitation (Measey, 2011).

While amphibians with large population sizes are buffered against the impacts of infrequent and extreme stochastic events, small populations do not have this resiliency. Events such as drought, fire, floods, storms, or temperature anomalies often go unrecorded in terms of their effects on populations, yet such information can provide valuable insight into the responses of species. For example, wildfires are a common ecological disturbance (Pilliod et al., 2003) that maintain several vegetation types (e.g., grasslands, fynbos, savanna/cerrado). Some studies have assessed the responses of amphibian communities to fire, although the effect tends to depend on the taxa involved as well as the ecological community that is being burned (e.g., Pilliod et al., 2003; Westgate et al., 2012). Many studies have capitalised on prescribed burns to examine before- and after-effects of fire on communities and species, but the effects of natural wildfires rely on serendipitous studies that are already ongoing in areas that burn (e.g., Hossack and Corn, 2007). Because of the stochasticity involved, the effect

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of fire on amphibian species and communities is not well known and has never been studied for amphibians that occur in the fire-dependent fynbos.

As small vertebrates, amphibians are often cryptic within the larger ecosystem and are most visible or audible when they congregate to breed. Thus, population monitoring for anurans is typically directed by their calls, particularly for collecting data on numbers of breeding sites and population abundance (e.g., Measey et al., 2017). However, not all amphibians have a breeding call, and for these species biologists rely on visual observations to carry out population monitoring. Natural history observations also form an important source of information particularly for voiceless species, and together these foundational data can be used to adaptively manage amphibian species at risk of extinction.

Capensibufo Grandison, 1980 is a genus of toads that occurs in the Cape Fold Mountains, South Africa. Most species do not have an advertisement call (Grandison, 1980), are very small (20–60 mm snout–vent length), narrowly endemic (Channing et al., 2017), and presumably dispersal restricted (Tolley et al., 2010). Rose's dwarf mountain toadlet, *C. rosei* (Hewitt, 1926), is one of three amphibian species endemic to the Cape Peninsula, a 470 km^2 mountainous area within the Cape Town municipality. These toads are observable for about 10–12 weeks as they congregate in ephemeral puddles at breeding sites during the austral winter (see Edwards et al., 2017 for a detailed phenology of breeding for *C. rosei*). Although individual toadlets are occasionally found outside of breeding periods, such observations are usually associated with rock flipping while surveying for other amphibians and reptiles. Hence it is not known where *C. rosei* individuals spend the harsh, dry summer months. Despite the entire distribution of *C. rosei* being contained within Table Mountain National Park, known breeding populations have suffered an enigmatic decline over the last 50 years (Cressey et al., 2015), making it Critically Endangered (SA-Frog and IUCN 2015). The decline is considered enigmatic because although a few populations have been lost due to land transformation and degradation, the majority of the historical populations occurred within the National Park, and these appear to have gone extinct (Cressey et al., 2015).

A large wildfire in March 2015 burned over one of the two known breeding sites (see Cowell and Cheney, 2017), allowing for an opportunity to examine how the population had survived the fire. That these mountain toads can survive fire is presumed, as they have evolved in this setting for millions of years (see Tolley et al., 2010), but this is an important ability to emphasise because 'frequent fires' are sometimes blamed for increased threat risk to anuran species in the fynbos (e.g., Measey, 2011).

Materials and Methods

An ongoing population monitoring project (e.g., Becker et al., 2018) has been annually tracking the few remaining breeding populations of *C. rosei* since 2008 (see Measey et al., 2019). From 1–4 March 2015, an extensive wildfire burnt approximately 2500 ha of Table Mountain National Park (Cowell and Cheney, 2017), including a *C. rosei* breeding site at the Silvermine section. Given that the species is Critically Endangered, the exact location of this site is withheld. Although access to the site was not allowed immediately after the fire, we were allowed to inspect our study site on 11 March 2015 (Fig. 1). Only one breeding puddle was observed near the southern wetland patch in 2014 (see Edwards et al., 2017), and we used this microsite to start our observations.

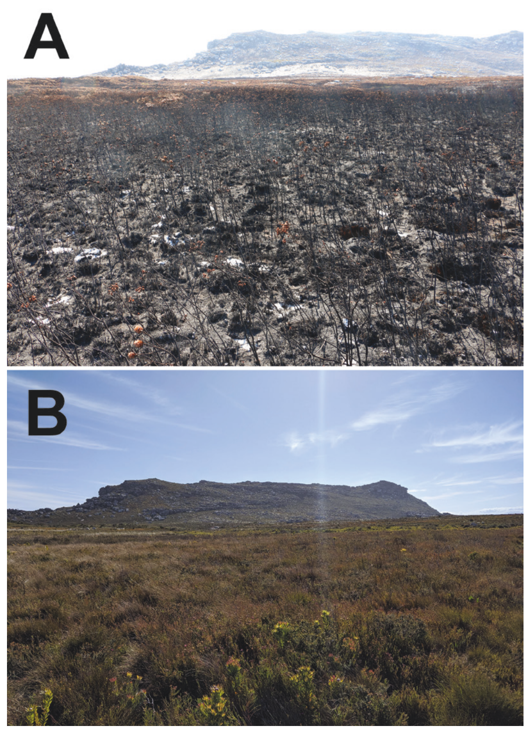

Figure 1. The vicinity of the *Capensibufo rosei* breeding site (A) immediately after the wildfire (11 March 2015), and (B) after 4 yrs of regrowth (10 November 2019). The wetland area had been dominated by a dense stand of Golden Conebush, *Leucadendron laureolum* (Lam.), that the fire burned away, allowing a clear view of the ash-covered substrate.

Within 10 min of arriving at the site where we had previously made regular breeding observations (Edwards et al., 2017; Becker et al., 2018), we spotted an adult *C. rosei* hopping through the ash, and as we followed it, we observed it disappearing into a small hole, presumably a burrow for a small mammal. The area had many of these small burrows, which we investigated by shining a torch into as many burrows as possible to spot additional toads. In many of the burrows, we could easily see these toads, particularly through their eye-shine in the torchlight. By prying into these burrows with a small stick, we found that many of the burrows contained several toads.

Following our initial observations, we conducted an additional survey of the area in May 2015, at the start of the austral winter, to map the extent of burrows occupied by *C. rosei*. A handheld GPS (Garmin GPSMap 64) was used to record positional data for each occupied burrow, and the overall area of these occupied burrows was mapped. Areas of ca. 10 m diameter where *C. rosei* were found to be absent after a thorough search were marked 'absent' during the search, which covered the vicinity of the wetland area surrounding the breeding site. The broader area of ca. 400 m radius around the breeding site was also checked for the presence of burrows and *C. rosei*. While the burrows formed a dense network within the peaty soil of the wetland area, the drier sandy soil with lower organic content surrounding it contained fewer burrows or any other places for *C. rosei* to shelter. Therefore, we focussed the search on the areas with visible peat or fine plant matter on the surface, which contained many burrows or crevices, and the immediately surrounding areas. Large tracts of soil with little or no visible surface peat (i.e., dry sandy patches) were also searched.

Results

Our initial observations, one week after the fire in March 2015, show that *C. rosei* use burrows during the daytime in the austral summer of the South African Cape (Fig. 2; see supplemental information video at https://youtu.be/YAvJ8_KQkrM), and probably used these same burrows to survive the fire. Some burrows also contained other anurans, including the clicking stream frog, *Strongylopus grayii* (Smith, 1849) and the Cape peninsula moss frog, *Arthroleptella lightfooti* (Boulenger, 1910). However, our initial observations were that *C. rosei* was the most frequent species in the occupied burrows.

Our survey in May 2015 showed that most of the toadlets still occupied the same area within 160 m of the breeding site as in March (Fig. 3). Their distribution was assessed by the occurrence of eye shine from burrows in the torchlight in the peaty wetland soil, in which they were hiding. We noted that areas where the soil was compacted (e.g., a footpath through the area) had no burrows or toads. The area occupied by toadlets was smaller than the wetland as a whole, and other nearby suitable patches with burrows were unoccupied. All recorded breeding sites occurred in close proximity to (< 20 m) or within wetland patches with a high density of burrows.

Discussion

These natural history observations suggest that the population of *C. rosei* at Silvermine occupies a small area very close to the breeding site. Although we cannot dismiss the idea that some individuals in this population may have been at a greater distance than the area we searched, it appears that the majority of animals are clustered in a very small area. During the breeding period, hundreds of males congregate in just a few shallow puddles (Edwards et al., 2017; Becker et al., 2018), and these new observations suggest that the majority of the breeding population are probably resident within ~150 m of the breeding site. It is noteworthy that we located suitable habitat nearby, with peaty substrate and rodent burrows, but these were unoccupied by toadlets. During the breeding period, suitable puddles appear to occur throughout the area (Edwards et al., 2017), but the only puddles occupied are those within the area where toads were found to occupy burrows. In the other known breeding area for *C. rosei* there are similarly few rocky outcrops or stones on the surface of the ground under which toads could take refuge, suggesting that they too may depend on burrows made by other species in a suitable organics-rich substrate. These refuges appear to be a way of escaping from the harsh, dry summer conditions in the Cape, but we suggest that these burrows also allow these toads to survive wildfires.

The fact that *C. rosei* use burrows suggests that they are vulnerable to substrate compaction in the immediate areas around their breeding site. At some of the historical sites, this may explain their enigmatic decline as areas may appear otherwise unchanged but could have undergone compaction. For example, Table Mountain receives approximately two million visitors annually (Richins et al., 2016), but once visitors arrive on top of Table Mountain (often by cable car) they can wander freely off the paths. One former breeding site, at the top of Platteklip Gorge, is a visitor hotspot. If *C. rosei* relies on burrows in uncompacted ground, this might explain why they are no longer found there. However, there are

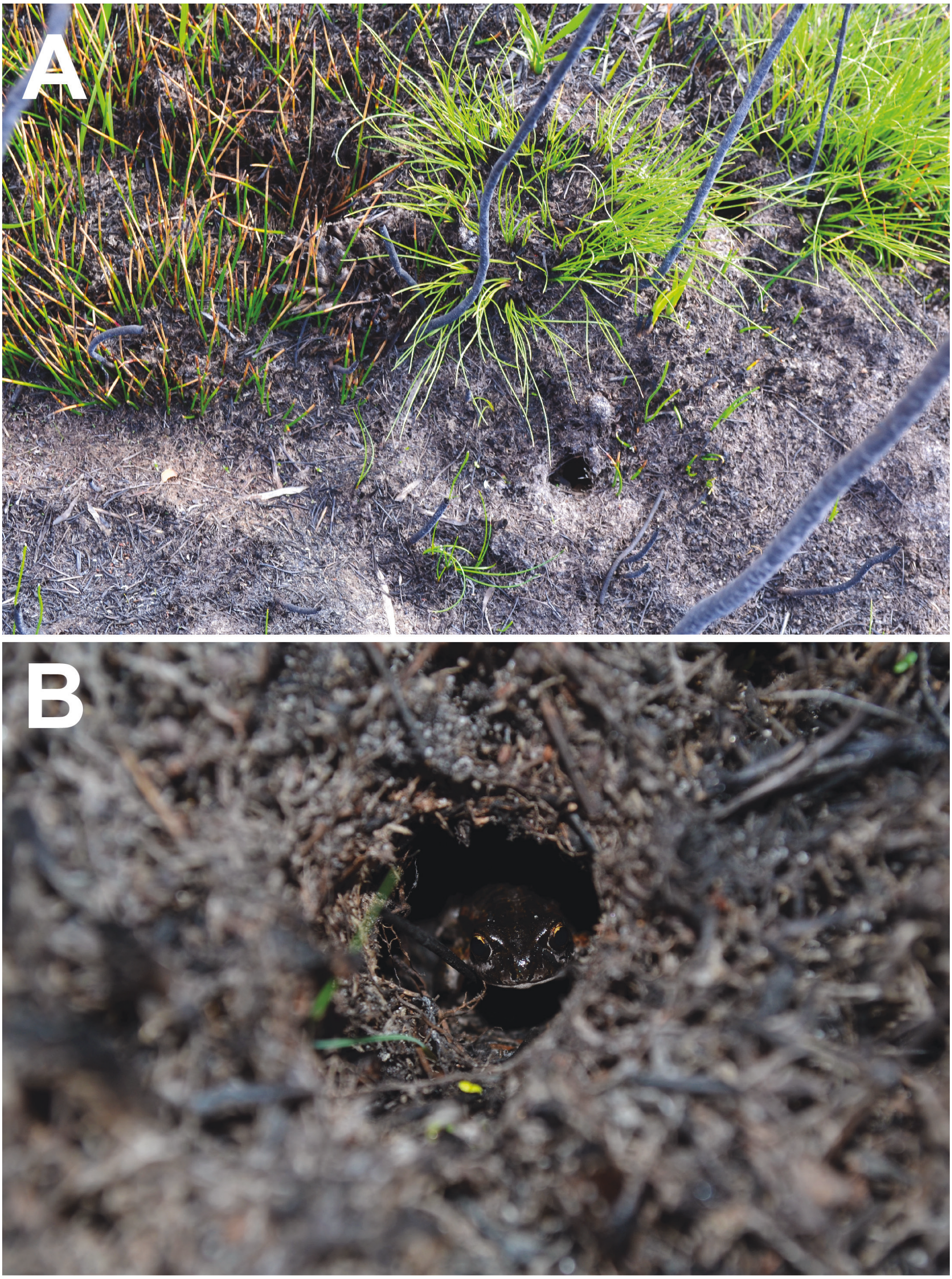

Figure 2. (A) A typical burrow on the burnt substrate of the fynbos near the breeding site of *Capensibufo rosei*. (B) an adult male *C. rosei* sits in a burrow surrounded by burnt fynbos.

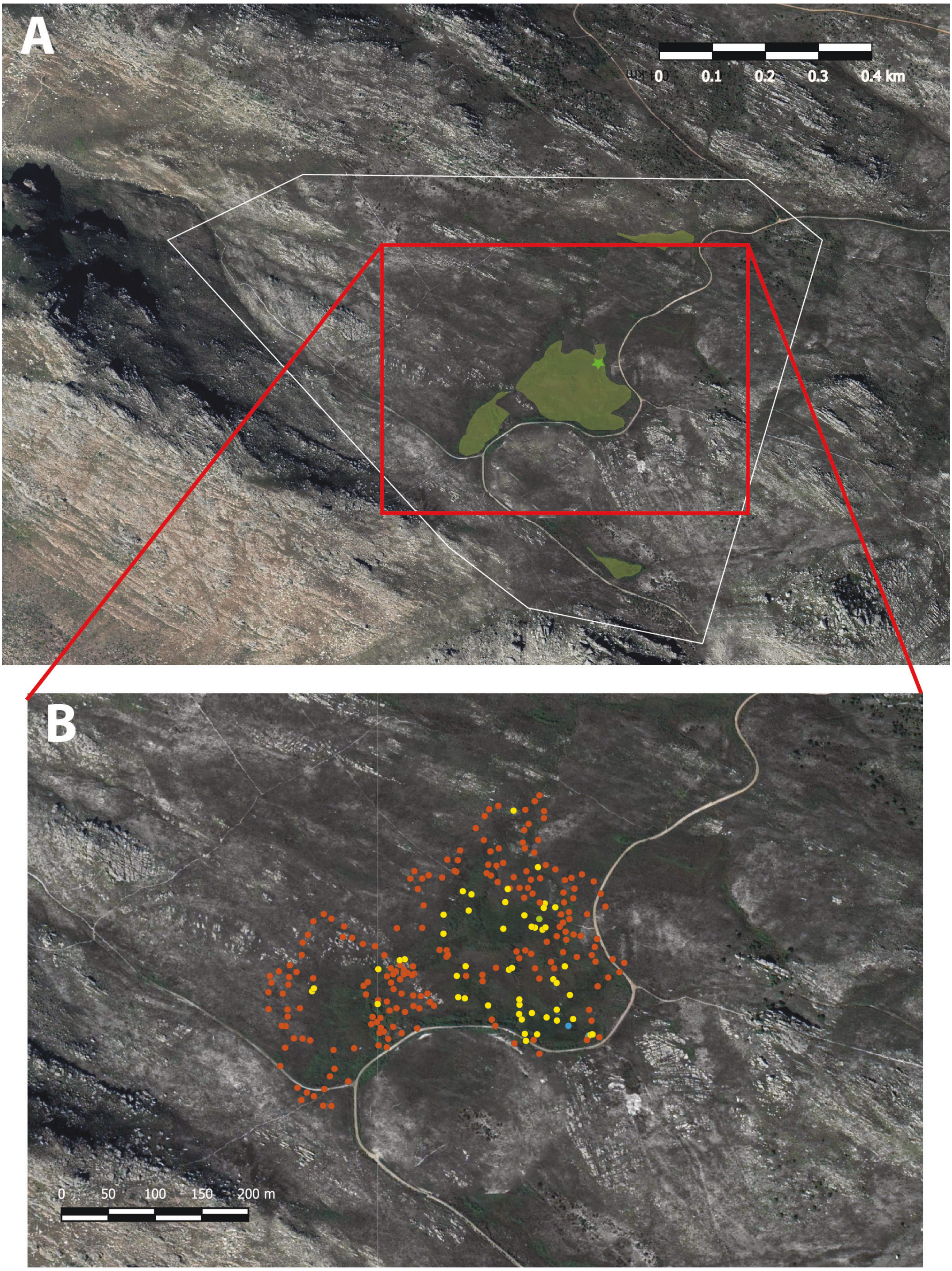

Figure 3. (A) The area searched for *Capensibufo rosei* in May 2015 (white polygon) and the four areas with suitable peaty substrate (green filled polygons). A green star indicates the position of the 2014 breeding puddle. (B) The presence of toads occupying burrows (yellow dots), and the localities of vacant burrows (orange dots). Presence of other species in burrows (blue dots). The back image to both figures has been altered to obfuscate the locality of these animals.

other potential explanations. Given that the surviving breeding site at Silvermine receives far fewer visitors, it is unlikely that site has undergone any compaction, and our anecdotal observations at the site would support that assertion. We therefore suggest that the remaining populations require zoning by Table Mountain National Park, to ensure that no compaction is allowed to occur in the immediate vicinity of breeding sites. In addition, the opportunistic mapping of breeding areas after fire, as we have done here, should be considered a high priority for helping plan active conservation of this species. Similar surveys of historic breeding sites (see Cressey et al., 2015) would also be of value.

Our observations show the value offered by researchers entering conservation areas immediately after fires or other extreme events. Although we have made numerous natural history observations on this species since our studies began in 2008, the fynbos vegetation was so dense that we would not have known that toadlets occupied burrows in this area had we not visited the site following the fire. Nor would we have known how these small toads survive fires that regularly impact their habitat. Fires may well act as agents of disturbance, clearing the habitat of dense vegetation and having a positive effect. As this species appears to prefer breeding in clearings, such disturbances may be beneficial by increasing open areas for potential breeding sites. Trends in the population following fires are still needed to understand their impacts on this threatened species. We already know that these toadlets experience considerable population stochasticity in relation to rainfall during the wet Cape winters. Using capture-mark-recapture approaches over seven years, the annual survival rate varied between 0.04 and 0.92, and 94% of this variation was explained by variation in breeding-season rainfall (Becker et al., 2018). Surprisingly, rainfall correlated negatively with survival, such that in periods with heavy rains, individuals spent more time at breeding sites and were thus less likely to survive to the next breeding season. It remains to be seen whether fire has positive or negative impacts on populations of *C. rosei*.

The size of the occupied burrows was typically 3–4 cm wide and 2–3 cm deep. This appears far too large to have been excavated by these small toads, which are typically 2–3 cm body length and have no digging tubercles on their feet. We suspect that the burrows were made by Cape gerbils, *Tatera afra* (Gray, 1830), because they are abundant in the area, live in wetlands such as these, and burrow into sandy substrates (Skinner and Chimimba, 2005). We observed fresh rodent droppings in a number of burrows. Cape gerbils are herbivores (Skinner and Chimimba, 2005), and perhaps is it possible that gerbils and frogs inhabit these burrows commensally, even under typical circumstances.

This study shows how opportunistic observations made after an extreme event (a fire) can provide valuable natural history knowledge about a cryptic amphibian. In this case, our observations have important implications for the conservation of a Critically Endangered fynbos endemic. Specifically, we suggest that our findings indicate that the core habitat for *C. rosei* is highly localised around their breeding area, and that significant alteration (including compaction) to this core habitat may rapidly result in the extirpation of a local population.

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